A CLINICAL STUDY OF PATIENTS PRESENTING WITH ACUTE KIDNEY INJURY AT A TERTIARY CARE HOSPITAL

N. Mahesh Babu[1], I. V. Ramachandra Rao[2], M. V. K. Hareesh[3]

[1]Postgraduate, Department of General Medicine, SVRR General Hospital / S. V. Medical College, Tirupati, Andhra Pradesh.
[2]Professor, Department of General Medicine, SVRR General Hospital / S. V. Medical College, Tirupati, Andhra Pradesh.
[3]Senior Resident, Department of General Medicine, SVRR General Hospital / S. V. Medical College, Tirupati, Andhra Pradesh.

ABSTRACT

BACKGROUND

AKI is a challenging problem in the tropics in view of the changing burden of the disease, the late presentation of patients to health care facilities and the lack of resources to support patients with established AKI in many regions. The mortality of patients with AKI in the tropics is unacceptably high. The treating physician in rural centers should be competent to treat trivial causes of AKI and refer those individuals who require critical care at the right moment.

MATERIALS AND METHODS

A prospective study of 100 patients admitted with Acute Kidney Injury (AKI) in S.V.R.R. Government General Hospital attached to Sri Venkateswara Medical College (SVMC) during the period of November 2010 to April 2013. Patients were diagnosed with AKI using RIFLE criteria based on Serum Creatinine estimation by Jaffe method and also estimating urine output and managed conservatively or with Haemodialysis.

RESULTS

Out of 100 patients presenting with Acute Kidney Injury (AKI), 33% of cases have been attributed to severe sepsis, 20% to gastroenteritis, 14 % to hair-dye poisoning, 8% to malaria, 6% to cardiorenal syndrome, 6% to snake bite, 3% to hepatorenal syndrome, 2% to obstructive uropathy, 2% to crush syndrome, 2% to heat stroke, 1% to obstetric-related caises, and 3% to miscellaneous causes. 55% of cases were managed with haemodialysis whereas 45% of cases were managed conservatively. Out of the 100 patients, 67% patients were discharged, 28% patients died, and 5 patients left against medical advice. Among 28 of patients who have died, severe sepsis (14 patients) was the most common cause attributing to the mortality (50%).

CONCLUSION

In our study, sepsis was the most common cause contributing to 33% of cases of AKI, with mortality upto 50%.
RIFLE criteria may help physicians to be aware of the risk of renal injury and in starting preventive or therapeutic intervention.

KEYWORDS

AKI, RIFLE Criteria, Sepsis.

HOW TO CITE THIS ARTICLE: Mahesh Babu N, Ramachandra Rao IV, Hareesh MVK. A clinical study of patients presenting with acute kidney injury at a tertiary care hospital. J. Evid. Based Med. Healthc. 2018; 5(36), 2635-2643. DOI: 10.18410/jebmh/2018/542

BACKGROUND

Acute Kidney Injury (AKI) is a complex syndrome for which no effective treatment exists. AKI complicates a wide variety of diseases and remains one of the major therapeutic challenges for the critical care physician.

AKI is characterized by rapid deterioration of renal function over a period of hours to days, resulting in the failure of the kidneys to excrete nitrogenous waste products and to maintain fluid and electrolyte homeostasis.[1] Although it is often associated with oliguria (urine volume <400 ml/day) or sometimes anuria (urine volume <100 ml/day), some patients may have normal or increased daily urine output (non-oliguric AKI – urine output >400 ml/day). Acute Kidney Injury (AKI) is a common disease process in the tropics with most of the data coming from studies based on referrals to dialysis units, and a few community based studies.[2]

In the West, AKI develops primarily in hospitalized patients with incidence varying from 5% in the overall hospitalized population up to 25% in the intensive care unit (ICU).[3] While the AKI in urban areas of the developing world simulates incidence in West, AKI occurring in the rural regions commonly develops in response to a single specific condition (e.g. Gastroenteritis), or infections, is more common in young (otherwise healthy) individuals, and is generally more severe, probably due to lack of availability of dialysis in rural areas; and where available, beyond the reach of the common man.

Financial or Other, Competing Interest: None.
Submission 14-08-2018, Peer Review 18-08-2018,
Acceptance 25-08-2018, Published 03-09-2018.
Corresponding Author:
Dr. M. V. K. Hareesh,
#28-5-427, A. P. Housing Board Colony,
MIG 311, Anantapur- 515001,
Andhra Pradesh.
E-mail: hareeshmvk@gmail.com
DOI: 10.18410/jebmh/2018/542

The possible pathogenic mechanisms for this higher occurrence of acute renal failure (ARF) in the tropics include a relative state of hypovolemia secondary to increased sweating and peripheral vasodilatation due to the hot climate, triggering of a haemolytic crisis in some ethnic groups who are glucose dehydrogenase deficient when they are exposed to certain drugs and toxins, and the endemic malnutrition in these regions predisposes the population to a large variety of infections.[4]

AKI is associated with high mortality, as quoted in the literature, anywhere from 45% to 60%.[3] Some of the possible reasons include the following-

1) **Inadequate Dialysis Prescription**
   Studies have shown that prescribed dialysis efficiency is rarely achieved in AKI, suggesting more intensive dialysis in the sicker AKI patients compared with more stable chronic dialysis patients.

2) **Inability of Dialysis to provide Actual Renal Replacement**.
   The endocrine, cytokine, and immunologic functions of the kidney are not being replaced with dialysis

3) **Delay in the Initiation of Dialysis**.
   The optimal timing of renal replacement therapy (RRT) remains a question and limited studies have suggested that early initiation of RRT might improve survival.

The persistently high mortality in these patients leaves no room for complacency in management. Patients with AKI present more often as unexplained acute uremic emergencies. Investigation, diagnosis, and initial management must often be completed within few hours. The priorities in this early phase are to manage acute uraemia and electrolyte abnormalities, in particular hyperkalaemia, to establish the reversibility of the renal failure and to define its cause. Early detection of underlying cause and its management will prevent progress from renal dysfunction to established renal failure (in most cases) and thus a need for haemodialysis by monitoring with simple and feasible tests like' serum creatinine and urinary output'.

Aims & Objectives

Aim

To study the clinical profile and outcome of patients presenting with AKI.

Objectives

1) To elucidate the incidence of various causes leading to AKI.

2) To document the degree of renal impairment and outcome (by RIFLE criteria) in various aetiologies to determine the prognosis.

MATERIALS AND METHODS

Study Design

A prospective study of 100 patients admitted with Acute kidney Injury (AKI) in S.V.R.R. Government General Hospital attached to Sri Venkateswara Medical College (SVMC) during the period of November 2010 to April 2013.

Sample Size

A total no. of 100 patients presenting with AKI during the period of study.

Inclusion Criteria

- Age more than 12 years.
- Patients presenting with abrupt cessation of urinary output (oliguria).
- Patients presenting with abrupt sustained rise in serum creatinine (estimated by Jaffe's method).

Exclusion Criteria

- Age less than 12 years.
- Patients of Chronic Kidney Disease.

Method of Study

A careful history was taken followed by general physical and systemic examinations. Baseline investigations followed by more relevant and specific investigations including Serum creatinine and Renal ultrasound were done as and when indicated.

The diagnosis of AKI done based on the RIFLE criteria. The serum creatinine was first estimated by Jaffe's method at the time of admission. Then the baseline serum creatinine was back-estimated using MDRD equation (by an electronic database) as recommended by ADQI and then appropriate grading of renal dysfunction was done using RIFLE criteria to classify patients.

Baseline serum creatinine =
75/186 X (age exp(-0.203)) X (0.742 if female) X (1.21 if African American)

AKI is diagnosed when serum creatinine rises ≥ 1.5-fold from the baseline value which is presumed to have occurred within one week.[5] In our study, we included patients with admission creatinine more than 1.5 mg/dL as having some form of renal dysfunction and back-estimated baseline creatinine.

Patients were managed either conservatively or with haemodialysis depending upon the clinical circumstances. Details of the history, physical examination and lab reports were noted down from time to time. At the time of discharge, serum creatinine was repeated.

RESULTS

A total number of 100 patients admitted between November 2010 to April 2013 were studied.

The study subjects were in the age group of 17 to 76, out of which, 50 were males and 50 were females, coming

from different districts i.e. Chittoor (72%), followed by Kadapa (17%), Nellore (8%), and Anantapur (3%).

The duration of hospitalization varied between 1 to 25 days average being 8 days.

Out of 100 patients presenting with acute kidney injury (AKI), 33% of cases were due to severe sepsis, 20% to gastroenteritis, 14 % to hair-dye poisoning, 8% to malaria, 6% to cardiorenal syndrome, 6% to snake bite, 3% to hepatorenal syndrome, 2% to obstructive uropathy, 2% to crush syndrome, 2% to heat stroke, 1% to obstetric-related, and 3% to miscellaneous causes.

Out of the 100 patients presenting with AKI, 53% were found out to be oliguric and 47% were non-oliguric.

According to RIFLE criteria, 17% were found to be in the 'risk' group, 27% in the 'injury' group, and 56% in the 'failure' group. Hair-dye poisoning predominated the 'risk' group with 4 cases (23.52%), gastro-enteritis was the most common cause with 'injury' (22.22%), while severe sepsis topped the list among patients presenting with 'failure' (50%) in our study.

Out of the 100 patients presenting with AKI, 55% of cases were managed with haemodialysis whereas 45% were managed conservatively. Out of 55 patients managed with haemodialysis, about 14 patients were managed with 4 sessions

Out of the 100 patients, 67% patients were discharged, 28% patients died (severe sepsis), and 5 patients left against medical advice.

Total no. of patients	100
Age in the years	17-76
Males and females	50+50
Range of hospitalization	1-25
Antecedent Causes	
• Severe sepsis	33
• Gastroenteritis	20
• Hair-dye poisoning	14
• Malaria	08
• Snake-bite	06
• Cardio-renal syndrome	06
• Hepatorenal syndrome	03
• Crush syndrome	02
• Heat stroke	02
• Obstructive uropathy	02
• Miscellaneous	04
RIFLE GRADING of renal dysfunction	
• Risk	17
• Injury	27
• Failure	56
Oliguric: non-oliguric	53: 47
➢ Management conservative: haemodialysis	45: 55
Outcome of the Patient	
• Recovered	67
• Left against medical advice	05
• Death	28

Table 1. Preliminary Data of the Study

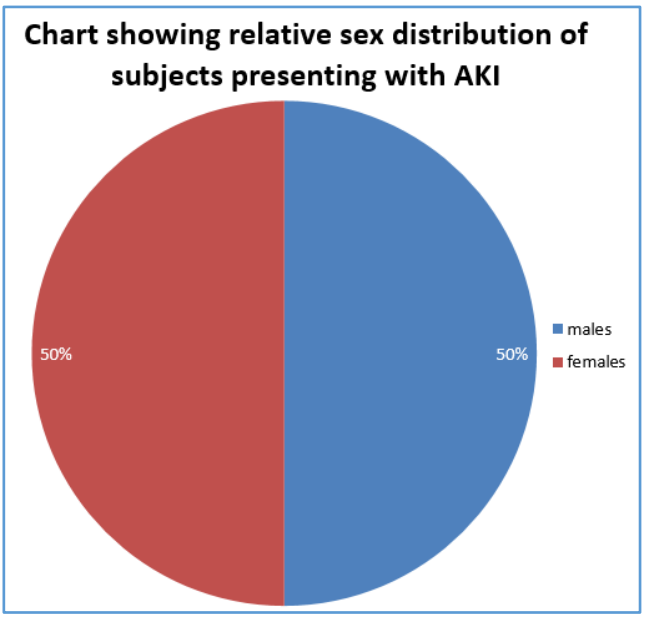


Chart 1

Age Group	No. of Patients
11-20	06
21-30	18
31-40	27
41-50	25
51-60	09
61-70	14
71-80	1

Table 2. Age Distribution

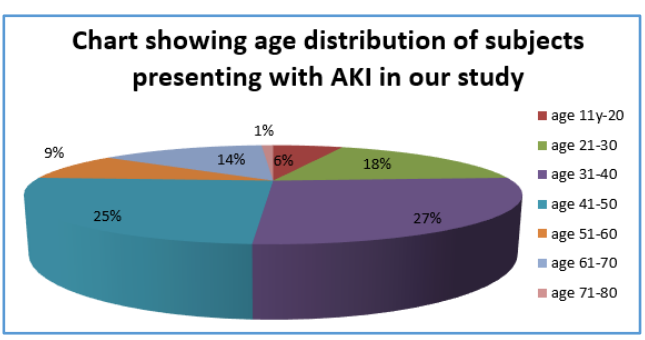
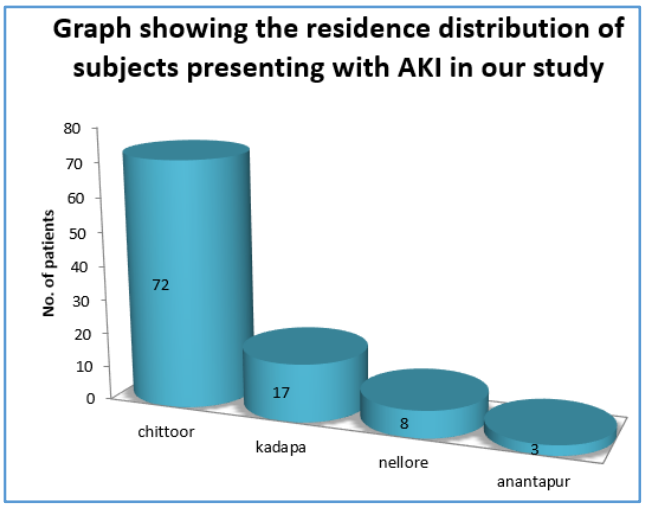


Chart 2

District	No. of Patients
Chittoor	72
Kadapa	17
Nellore	08
Anantapur	03

Table 3. Residence Distribution



Graph 1

Antecedent Cause	No. of Patients
• Malaria	08
• Gastroenteritis	20
• Hair-dye poisoning	14
• Severe sepsis	33
• Snake bite	06
• Cardiorenal syndrome	06
• Hepatorenal syndrome	03
• Heat stroke	02
• Obstructive uropathy	02
• Crush syndrome	02
• Miscellaneous	04

Table 4. Aetiology of Acute Kidney Injury (AKI)

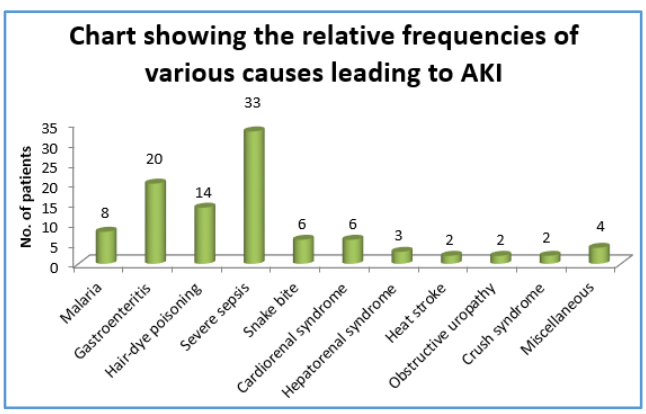
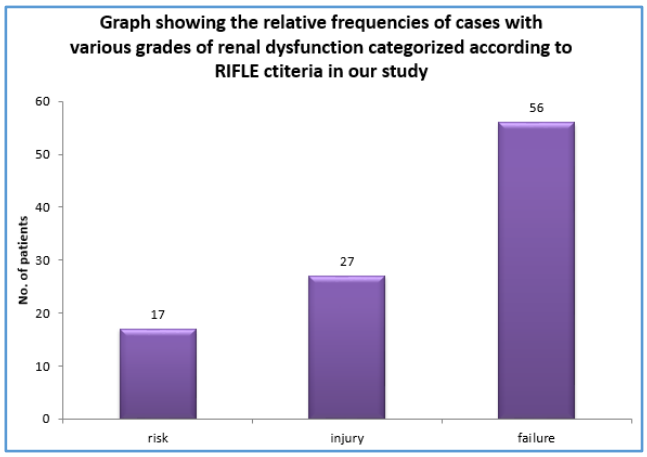


Chart 3

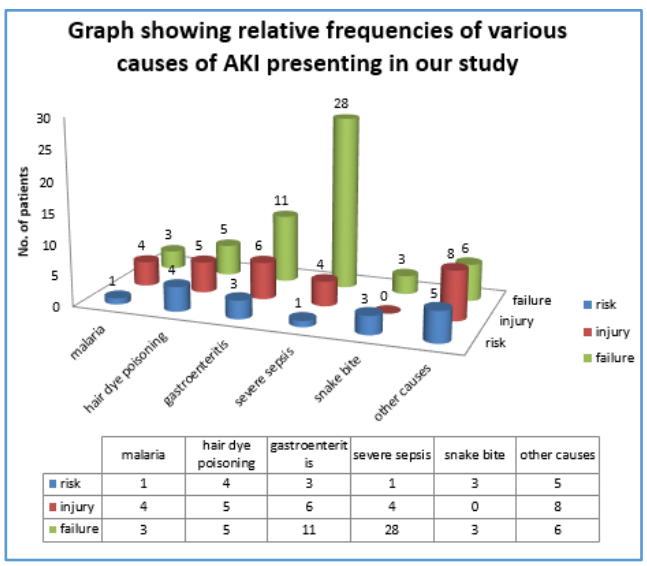
Chart 3 showing Frequency distribution of patients with various grades of renal dysfunction classified on the basis of RIFLE criteria.

RIFLE Group	No. of Patients
Risk	17
Injury	27
Failure	56

Table 5



Graph 2. Frequency Distribution of Various Causes of AKI in Our Study and RIFLE Categorization of Patients

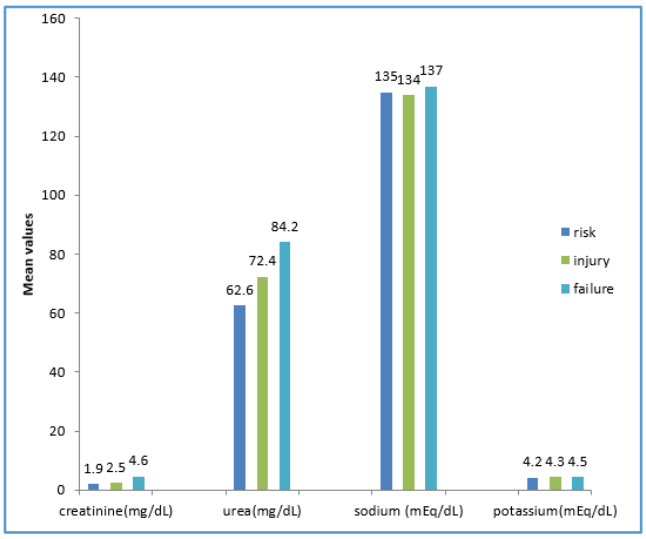


	malaria	hair dye poisoning	gastroenteritis	severe sepsis	snake bite	other causes
risk	1	4	3	1	3	5
injury	4	5	6	4	0	8
failure	3	5	11	28	3	6

Graph 3

	Risk (Mean ± S.D.)	Injury (Mean ± S.D.)	Failure (Mean ± S.D.)
Creatinine (mg/dL)	1.9 ± 0.2	2.5 ± 0.6	4.6 ± 1.8
Urea (mg/dL)	62.6 ± 16.8	72.4 ± 17.4	84.2 ± 18.2
Sodium (mEq/dL)	135 ± 6.7	134 ± 9.2	137 ± 9.9
Potassium (mEq/dL)	4.2 ± 0.7	4.3 ± 1.1	4.6 ± 0.9

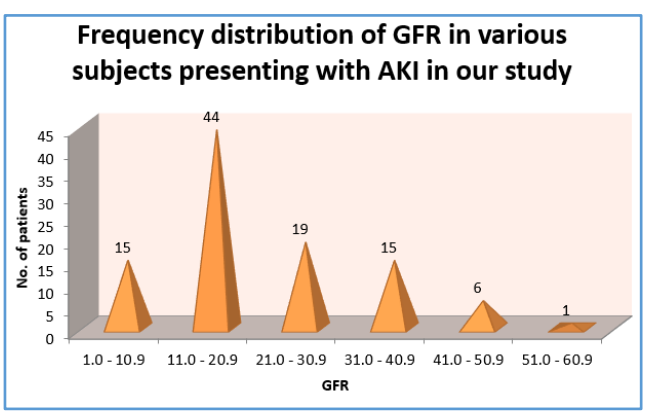
Table 6. Mean and SD Values of Various Biochemical Parameters in AKI in different 'RIFLE' Groups



Graph 4

GFR	No. of Patients
1.0 – 10.9	15
11.0 – 20.9	44
21.0 – 30.9	19
31.0 – 40.9	15
41.0 – 50.9	06
51.0 – 60.9	01

Table 7. Frequency Distribution of Patients Based on GFR



Graph 5. Frequency Distribution of Patients Based on their Urinary Output

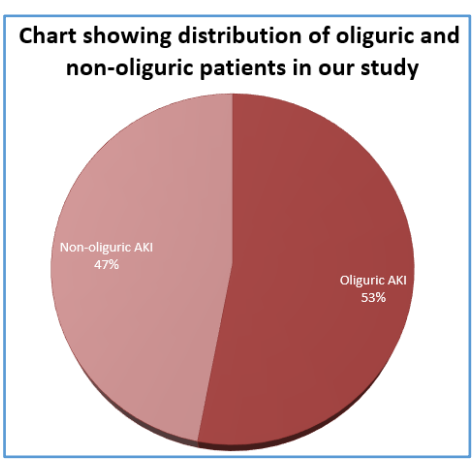
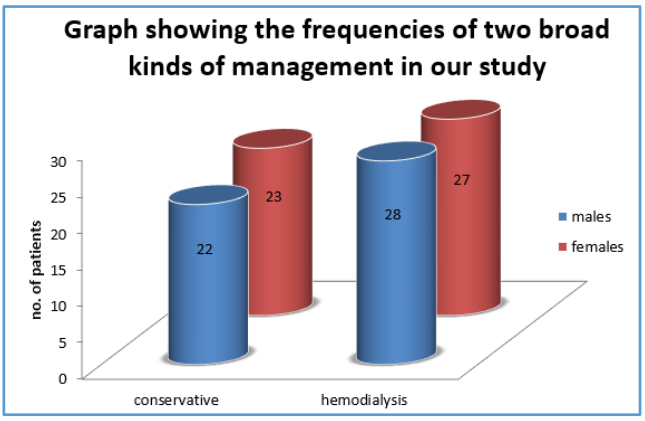


Chart 4

	Males	Females
Conservative	22	23
Haemodialysis	28	25

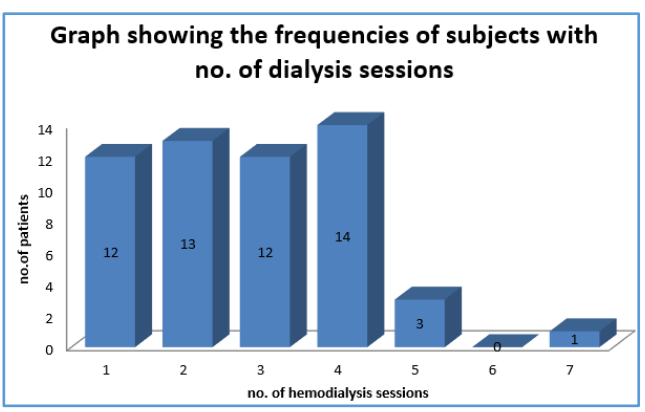
Table 8. Frequency Distribution of Management Categories



Graph 6

No. of Sessions	No. of Patients
1	12
2	13
3	12
4	14
5	3
6	0
7	1

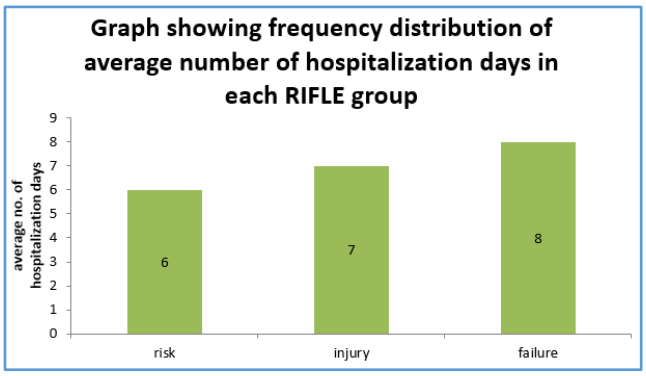
Table 9. Frequency Distribution of No. of Dialysis Sessions in Our Study



Graph 7

RIFLE Group	Average No. of Hospitalization Days
Risk	6
Injury	7
Failure	8

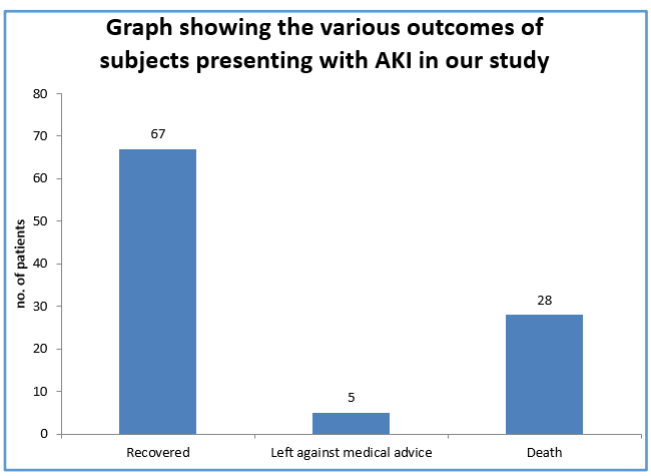
Table 10. Frequency Distribution of Average Number of Hospitalization Days of Various Subjects in Different RIFLE Groups



Graph 8

Outcome	No. of Patients
Recovered	67
Left against medical advice	05
Death	28

Table 11. Frequency Distribution of Various Outcomes Of Subjects Presenting With AKI In Our Study

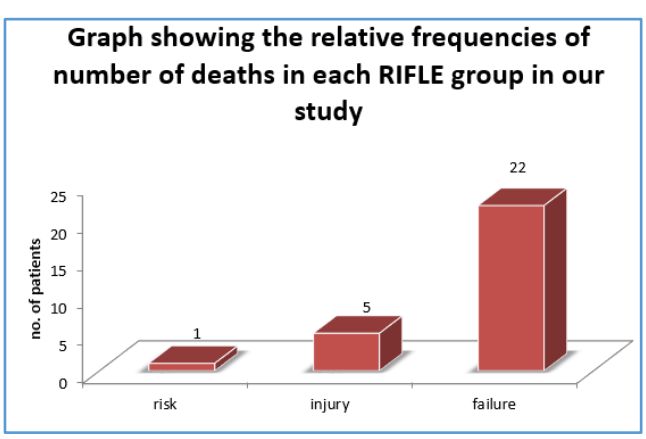


Graph 9

RIFLE Group	No. of Patients
Risk	1(5.88%)
Injury	5(18.51%)
Failure	22(39.28%)

Table 12. Frequency Distribution of Deaths in Three RIFLE Groups of Our Study

χ^2 test = 8.87; 'p' value = 0.011; Significant.



Graph 10

DISCUSSION

The results and observations of present study were discussed under following headings:

A) Clinical Epidemiology

- The lack of a uniform definition, the paucity of multicentric, large studies, and under-reporting in the tropics due to local conditions have created a void in the proper understanding of the epidemiology of AKI.[6] A variety of prospective studies, using the new definition and staging system of AKI are needed to understand epidemiological trends for this disease in the tropics.[7]
- Acute kidney injury (AKI), characterized by a reversible decline in the glomerular filtration rate, leading to retention of nitrogenous waste products and an inability to maintain fluid and electrolyte homeostasis, remains one of the most enigmatic problems, with reported incidence rates between 25% and 80%.[8]
- In contrast to the mean age of around 72 years in patients with AKI in the temperate zone,[9] in India it was 37.1 years.[10] In our study, the mean age of the subjects was around 42 years.
- There were no significant gender-related differences in the incidence of AKI reported in the literature.[11] In our study, there were 50 males and 50 females.
- Infections remain the major culprit in most cases of AKI, with high mortality rates in the tropics.[12] In our study, the three most common causes contributing to AKI include severe sepsis, gastroenteritis, and hair-dye poisoning which was in accordance with the Mathew and George et al., study.
- The beginning and ending supportive therapy (BEST) kidney investigators highlighted the fact that sepsis is the most common cause of AKI in critically ill patients (47.5%), after evaluating a varied population, in 54 hospitals spread over 23 countries.[13] In our study, the reported incidence of AKI secondary to severe sepsis was 33%.
- Although the incidence of diarrheal disease-related acute renal failure has decreased from 23% in the 1960s to <10%, still continues to be a major cause of AKI necessitating emergency dialysis therapy.[14] In our study, the reported incidence was 20%.
- Hair-dye poisoning is a rare cause of AKI and accounted for about 0.6% of all cases of AKI in a study by Manisha and Vani et.al (unpublished data.[15] In our study, the reported incidence was 14%.
- Malarial AKI occurs in less than 1% to 5% of all cases of AKI in endemic areas, whereas the prevalence in nonimmune individuals is around 25% to 30%.[16] In our study, malaria contributed to 8% of cases of AKI.

B) RIFLE CRITERIA[17]: Incidence and Mortality Studies

Since the first publication of the RIFLE criteria in 2004 there have been more than 30 articles examining the epidemiology of AKI using the RIFLE criteria[18]. The incidence and outcome of AKI has varied according to population (ICU, non-ICU and population-based), parameters used for the criteria (serum creatinine, GFR and urine output) and timing of end-point (in-hospital mortality, 30 days, 60 days or six months).

- Hoste et al.[19] performed a retrospective single study on 5, 383 critically ill patients in 7 ICUs admitted during a one-year period. With incidence 0f AKI, in 67% of patients, with 12% achieving a maximum class of 'risk', 27% 'injury' and 28% 'failure'. Patients with a maximum score of 'risk' had a mortality rate of 8.8%, compared with 11.4% for 'injury' and 26.3% for 'failure'.
- Uchino et al.[20] focused on the predictive ability of the RIFLE classification in a cohort of 20, 126 patients admitted to a teaching hospital for more than 24 hours over a three-year period using serum creatinine levels from an electronic laboratory database to classify patients into 'risk', 'injury' and 'failure' groups and followed them to hospital discharge or death. Nearly 10% of patients achieved a maximum classification of 'risk', 5% 'injury' and 3.5% 'failure'.
- The North East Italian Prospective Hospital Renal Outcome Survey on Acute Kidney Injury (NEIPHROS-AKI), demonstrated the incidence of AKI in 19 ICUs in the three regions in north-eastern Italy during a three-month period.[21] Of 2, 164 ICU patients, 234 (10.8%) developed AKI, 19% were 'risk', 35% 'injury' and 46% 'failure'.[22] Overall mortality was highest among those in the 'failure' group (mortality: 20% 'risk', 29.3% 'injury' and 49.5% 'failure').
- In the first population-based study of AKI, Ali et al.[23] studied the incidence of AKI in Northern Scotland, a geographical population base of 523, 390. The incidence of AKI was 1, 811 per million population. Sepsis was a precipitating factor in 47% of patients.
- Ostermann and Chang[24] retrospectively analysed a database of 41, 972 patients admitted to 22 ICUs in the UK and Germany between 1989 and 1999 as part of the Riyadh Intensive Care Programme database. AKI defined by RIFLE occurred in 15, 019(35.8%) patients: 7207 (17.2%) 'risk', 4613(11%) 'injury' and 3199(7.6%) 'failure'. Hospital mortality rates were 20.9% for the risk group, 45.6% for 'injury' group, and 56.8% for 'failure' group.
- Finally, in the largest study to date, Bagshaw et al.[25] studied 120, 123 patients admitted to one of 57 ICUs across Australia for at least 24 hours from January 2000 to December 2005. In striking similarity to the study by Ostermann and Chang, AKI occurred in 36.1%, with a maximum category 'risk' in 16.3%, 'injury' in 13.6% and 'failure' in 6.3%. The crude hospital mortality by RIFLE category was 17.9% for 'risk', 27.7% for 'injury' and 33.2% for 'failure'.
- In our study, 100 patients were studied and categorized based on RIFLE criteria into 3 groups of renal dysfunctions. There were 17 subjects in the 'risk' group, 27 in the 'injury' group and '56' in the 'failure' group. Out of 100 patients, 28 subjects died, 1 from the risk group (5.88%), 5(18.51%) from the 'injury' group, and 22(39.28%) from the 'failure' group. A significant statistical correlation was found to exist in that there was increase in mortality with increasing RIFLE class.

Reference	N (Total)	Population Studied	Type of Study	Single Center/ Multi-Center	Criteria used for Rifle	Time of End-Point	Mortality (%)
Hoste et al., 2006	5383	ICU	Retrospective	single	Cr, UO	In hospital	R: 8.8 I: 11.4 F: 26.3
Uchino et al, 2006	20, 126	ICU	Retrospective	Multi-center	Cr, GFR	30 days	R: 15.1 I: 29.2 F: 41.1
Cruz et al, 2007	2164	ICU	Prospective	Multi-center	Cr, UO	60 days	R: 20 I: 29.3 F: 49.5
Ali et al, 2007	5321	Population - based	Retrospective	Multi-center	Cr, GFR	6 mon	R: 46 I: 48 F: 56
Ostermann and Chang, 2007	41, 972	ICU	Retrospective	Multi-center	Cr, GFR	In hospital	R: 20.9 I: 45.6 F: 56.8

Bagshaw 2008	120, 123	ICU	Retrospective	Multi-center	Cr, UO	In hospital	R: 17.9 I: 27.7 F: 33.2
Our study	100	ICU/ hospital-based	Prospective	Single center	Cr	In hospital	R: 5.8 I: 15.8 F: 39.2

Table 13. Epidemiological Studies of Acute Kidney Injury

C) RIFLE CRITERIA: Morbidity–Length of Hospital Stay-

- One study (Hoste et al.) reports an incremental length of stay by severity of AKI assessed by the RIFLE criteria: length of stay for patients with AKI 'risk' 8 days, 'injury' 10 days, and 'failure' 16 days[26].
- In our study, the average length of stay for patients with AKI in our study was 6 days for 'risk' group, 7 days for 'injury' group, and 8 days for 'failure' group.

CONCLUSION

- Acute deterioration of kidney function is a world-wide health problem with increasing incidence, prevalence, high costs, and poor outcomes.
- In reviewing the incidence of acute kidney failure requiring dialysis in intensive care settings, critical care experts formed Acute Dialysis Quality Initiative (ADQI) with RIFLE criteria and subsequently the establishment of a broader inter-organizational group, the Acute Kidney Injury Network (AKIN). The work of these two groups has been instrumental in defining the spectrum, establishing the risks, and addressing the clinical challenges posed by AKI.
- The burden of AKI is most significant in developing countries with limited resources for the care of these patients with the disease progressing to kidney failure necessitating renal replacement therapy, hence the detection of AKI in its early and potentially reversible stages is of paramount importance.
- Sepsis due to bacterial invasion, parasitic and viral infections, toxins and acute diarrheal diseases still top the list in the aetiology of AKI in the tropics.
- Sepsis-induced AKI is assuming a distinct identity of its own with a unique pathophysiologic mechanism, behaviour and outcome. Since majority of the patients with sepsis already have some degree of renal damage before the time of detection, by conventional means (RIFLE criteria) it seems logical to give serious consideration to facilitating recovery of renal function[27]. In our study, sepsis was the most common cause contributing to 33% of cases of AKI, with mortality upto 50%.
- Mortality rates for ARF have changed little since the advent of dialysis at 50%. Because most cases of community-acquired Acute Renal Failure (ARF) are secondary to volume depletion, as many as 90% of cases are estimated to have a potentially reversible cause. Hospital-acquired ARF often occurs in an intensive-care-unit (ICU) setting and is commonly part of multiorgan failure. This dichotomy in the aetiology of ARF explains the increased mortality rate, dialysis requirements, and rates of progression to end-stage renal failure seen in hospital-acquired ARF compared with community-acquired ARF. In our study, the mortality rate was about 28%; risk 1 patient, injury 5 patients, and failure 22 patients.
- RIFLE criteria may help physicians to be aware of the risk of renal injury and in starting preventive or therapeutic intervention. In our study, 17% were in the 'risk' group, 27% in the 'injury', and 56% in the 'failure' group. Moreover, there was a linear increase in mortality with increasing RIFLE class with patients at 'risk' contributing to 5.88%, 'injury' group to 18.51%, and 'failure' group to 39.28% in our study. These results were in accordance with other epidemiological studies.[19,20,22,23,24]

REFERENCES

[1] Kalra OP, Bhalla AK, Ojha S. Renal disease: prevention and management. The Association of Physicians of India. Indian College of Physicians 2008;19:136-144.

[2] Wang Y, Cui Z, Fan M. Hospital-acquired and community-acquired acute renal failure in hospitalized Chinese: a ten-year review. Renal Failure 2007;29(2):163-168.

[3] Vijayan A. Overview and Management of AKI and ATN: The Washington University Nephrology Subspeciality Consult 2008;11:94-106.

[4] Jain S, Suri V. Acute renal failure in the tropics: Medicine Update. 2009:746-753.

[5] Lewington A, Kanagasundaram S. The renal association: acute kidney injury. Summary of clinical practice guidelines for AKI. http://www.renal.org/Clinical/GuidelinesSection/Acute Kidney Injury.aspx 2010; 1.1: 9.

[6] Lameire N, Ven Biesen W, Vanholder R. The changing epidemiology of acute renal failure. Nat Clin Pract Nephrol 2006;2(7):364-377.

[7] Bellomo R, Ronco C, Kellum JA, et al. Acute renal failure - definition, outcome measures, animal models, fluid therapy and information technology needs: the Second International Consensus Conference of the acute dialysis quality initiative (ADQI) group. Crit Care 2004;8(4):R204-212.

[8] Lameire N, Van Biesen W, Vanholder R. Acute renal failure. Lancet 2005;365(9457):417-430.

[9] Waikar SS, Curhan GC, Wald R, et al. Declining mortality in patients with acute renal failure, 1988 to 2002. J Am Soc Nephrol 2006;17(4):1143-1150.

[10] Jayakumar M, Prabahar MR, Fernando EM, et al. Epidemiologic trend changes in acute renal failure--a tertiary centre experience from south India. Ren Fail 2006;28(5):405-410.
[11] Ali T, Khan I, Simpson W, et al. Incidence and Outcomes in AKI: a comprehensive population-based study. J Am Soc Nep 2007;18(4):1292-1298.
[12] Mathew AJ, George J. Acute kidney injury in the tropics. Ann Saudi Med 2011;31(5):451-456.
[13] Bagshaw SM, Uchino S, Bellomo R, et al. Septic AKI in critically ill patients: clinical characteristics and outcomes. Clin J Am Soc Nephrol 2007;2(3):431-439.
[14] Chugh KS, Narang A, Kumar L, et al. Acute renal failure amongst children in a tropical environment. Int J Artif Organs 1987;10(2):97-101.
[15] Sahay M, Vani R, Vali S. Hair dye ingestion--an uncommon cause of acute kidney injury. J Assoc Physicians India 2009;57:743-744.
[16] Mishra SK, Das BS. Malaria and acute kidney injury. Semin Nephrol 2008;28(4):395-408.
[17] Kellum JA, Srisawat N. Acute kidney injury – definition and classification. European Critical Care & Emergency Medicine 2010;2:42-45.
[18] Ricci Z, Cruz D, Ronco C. The RIFLE criteria and mortality in acute kidney injury: a systematic review. Kidney Int 2008;73(5):538-546.
[19] Hoste EA, Schurgers M. Epidemiology of acute kidney injury: how big is the problem? Crit Care Med 2008;36(4 Suppl):S146-151.
[20] Uchino S, Bellomo R, Goldsmith D, et al. An assessment of the RIFLE criteria for acute renal failure in hospitalized patients. Crit Care Med 2006;34(7):1913-1917.
[21] Molitoris BA. Acute kidney injury. In: Goldman L, Ausiello DA, Arend W, et al, eds. Cecil medicine. 23rd edn. Saunders Elsevier 2007:862-866.
[22] Cruz DN, Bolgan I, Perazella MA, et al. North East Italian prospective hospital renal outcome survey on acute kidney injury (NEiPHROS-AKI): targeting the problem with the RIFLE Criteria. Clin J Am Soc Nephrol 2007;2(3):418-425.
[23] Ali T, Khan I, Simpson W, et al. Incidence and outcomes in acute kidney injury: a comprehensive population-based study. J Am Soc Nephrol 2007;18(4):1292-1298.
[24] Ostermann M, Chang RW. Acute kidney injury in the intensive care unit according to RIFLE. Crit Care Med 2007;35(8):1837-1843.
[25] Bagshaw SM, George C, Bellomo R. A comparison of the RIFLE and AKIN criteria for acute kidney injury in critically ill patients. Nephrol Dial Transplant 2008;23(5):1569-1574.
[26] Hoste EA, Clermont G, Kersten A, et al. RIFLE criteria for acute kidney injury are associated with hospital mortality in critically ill patients: a cohort analysis. Crit Care 2006;10(3):R73.
[27] Majumdar A. Sepsis-induced acute kidney injury. Indian J Crit Care Med 2010;14(1):14-21.